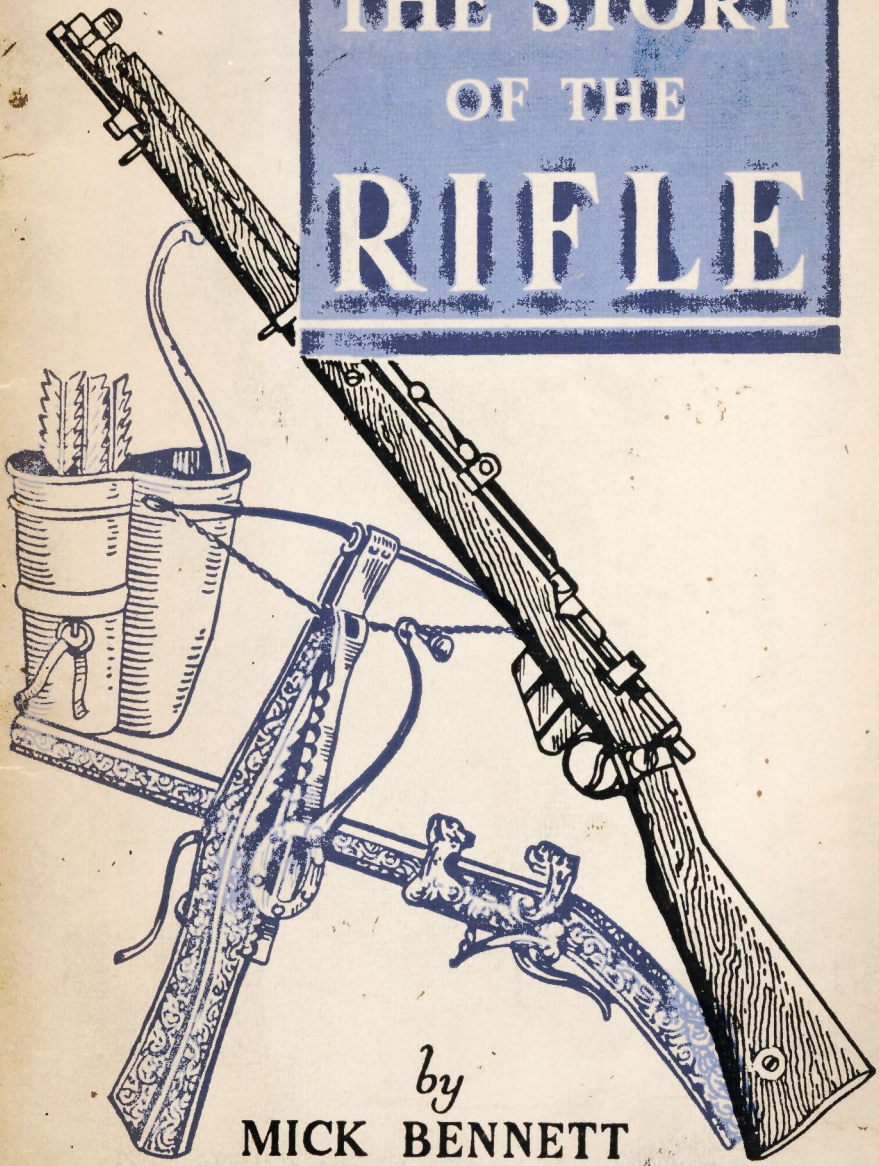
THE STORY OF THE RIFLE



by

MICK BENNETT

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THE STORY OF THE RIFLE

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"As good historically as
it is interesting to read."
Capt. B. H. Liddell Hart.

INTRODUCTION.

Amidst the many marvels of modern weapons, be the guns that throw shells for 30 miles, 50-ton tanks that crash along at 50 miles an hour, or planes that dive at 650 miles an hour, the rifle looks and sounds a very small commonplace affair, hardly worth getting excited about.

But its story, its evolution and development, is part of the history of the society and of the warfare of the past six centuries.

The word rifle comes from the German "riffeln" meaning "to groove." The rifle is a hand gun, the barrel of which contains a system of spiral shaped grooves known as rifling. We shall see later in this book the world shaking changes brought about by this seemingly simple development.

If we interpret the term rifle to-day in its broadest sense to mean a one-man firearm (including automatic rifle and tommy-gun) then it is a fact that the rifle is still the basic unit of fire-power in all armies. The number of soldiers in modern armies using the rifle is greater than those using all other weapons put together.

The rifle to-day is a weapon of the people; its extensive use in the forces, home guard and youth pre-service training organisations makes it a weapon well known to millions. Indeed, the number of rifles in use to-day is as great as the number of bicycles.

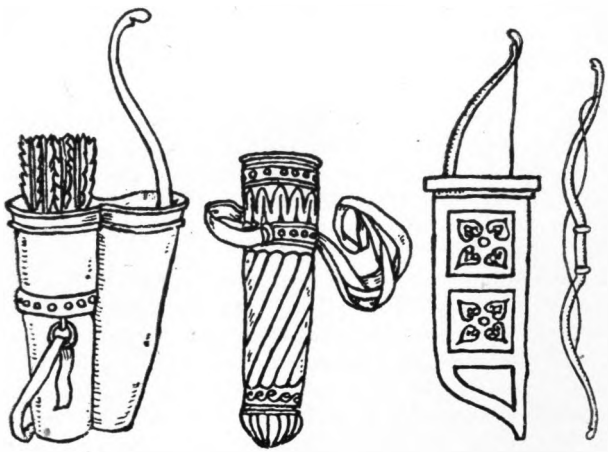
About one in every eight of the population of this country now has in his or her possession, or has access to, a rifle. In July, 1914, only one in every eighty were so placed.

As the modern rifle developed from its smooth bore musket forebears to its present place, it has witnessed some extraordinary changes. This can perhaps be most clearly grasped if it is realised that a single company of automatic riflemen can maintain a greater concentration of firepower than could the entire infantry of Cromwell's New Model Army of 300 years ago.

BEFORE FIREARMS.

When in earliest times man wanted to hurl a missile at an animal or fellow man, he relied solely on his own muscular energy; in other words, he picked up a stone and hurled it through the air at his target.

He not only learned how to use his hands, but how to make tools to help him to survive and get his living. A weapon is a form of tool, and, indeed, the first weapons weren't made for war purposes, because there were no wars, they were made to fight animals for food and protection. As man's intelligence grew, he began to invent things, and one of the most important inventions in human history was the method of throwing missiles other than by hand. There were many such inventions: slings, catapults, but the invention that played the greatest and most lasting part, was the bow and arrow.



A selection of Greek bows.

With the aid of a bow and arrow, man could add greatly to his diet, he could be more certain of catching game and fish, which, with the aid of fire (the use of which was discovered before the invention of the

bow and arrow) gave him greater nourishment, and also made him more and more independent of climate and locality. The invention of the bow and arrow was, therefore, of outstanding importance from the social point of view.

The bow and arrow was in use for many thousands of years, and all the armies of classical or ancient times (Egyptians, Assyrians, Babylonians, Greek and Roman) included archers.

From the scientific, technical point of view, the great importance of the bow and arrow is that it was a definite stage in advance of the principle of hurling missiles by sheer muscular energy.

It was a mechanical invention. It created a mechanical means whereby muscular energy could be concentrated, or stored up, and then suddenly released. Not only could the energy be stored up, it was greatly increased. With the aid of the string, the bow was bent by muscular effort and a great amount of energy became concentrated and imparted to the arrow by the sudden release of the string. Thus the arrow sped on its way, further, faster and surer than any man could throw it.

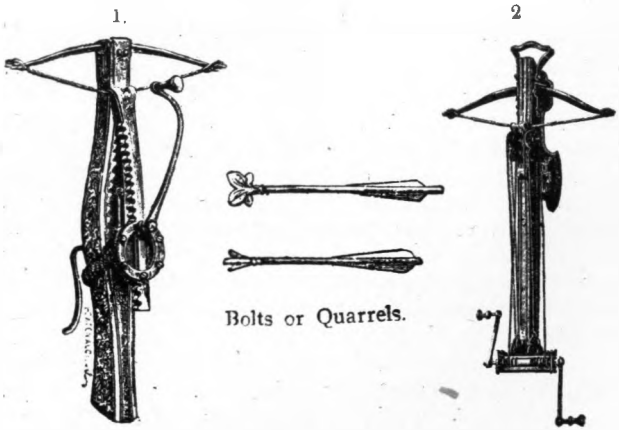
The principle of firearms is very much the same. The difference with firearms is that it is not muscular, but explosive energy that is stored and concentrated, while the means of concentrating this energy is chemical instead of mechanical (originally gunpowder, later other chemical compositions).

A transitional step from bow and arrow to firearm, was the crossbow. For a long time the crossbow was more effective than the hand gun and lasted roughly 500 years in military affairs, from the 12th to the 17th century. As to why it lasted for so long after firearms appeared, the answer is to be found in the productive level of society, in the technical means which existed. While the available technical means were sufficient to produce very effective crossbows, they were for a long time insufficient for producing effective firearms. Only when a musket could be produced that would far outrange any bow, could the reign of firearms be established, but for a long time it was found to be too

difficult to make barrels strong enough to withstand the pressure needed to give the gun the longer range.

It should be pointed out here that developments in this country were somewhat different from those of other lands. In England a superior type of bow, known as the longbow, made its appearance in the 13th century. It originated in Wales and became known to the English during the Welsh wars of Edward I.

The English peasants and artisans became masters of the longbow and it largely superseded the crossbow in England for a very long time. It was the best weapon of the peasants in the great revolt of 1381 led by Wat Tyler and John Ball. Its length and the greater distance that the string was pulled back and bow bent, gave it a terrific power. A longbow arrow could pierce an inch of oak at 200 yards, and because of its simplicity a far more rapid rate of fire could be maintained than with the crossbow which took so long to "load." English archery won the famous Battle of Crecy (1346) against the French feudal cavalry and the famous Genoese crossbowmen.



Two crossbows used in France in the Middle Ages.
1.—Lever Crossbow.
2.—Rolling purchase crossbow.

Later, however, superior crossbows were also used in England and even as late as Queen Elizabeth's reign (latter half of 16th century) the crossbow played a part in English armed forces. Somes of the later crossbows were considerable mechanical contraptions. There were some with wheels and ratchets, others with pulleys, yet others with a barrel; very close in the mechanical sense to the gun.

The missiles used in crossbows and known as quarrels or bolts usually had a head shaped like a four-sided pyramid and were feathered with wood or brass. There was one kind of bolt which was feathered in such a way as to cause it to rotate upon its axis (i.e., like a drill) as it hurled through the air. This is an example of how people in those days saw the advantage of a long-shaped missile which rotated upon its axis. It is precisely the same scientific principle that governs the rifle.

GUNPOWDER.

The advent of gunpowder was one of the most historical and world-shaking events. It was destined to speed up the end of the feudal system and make way for the capitalist system.

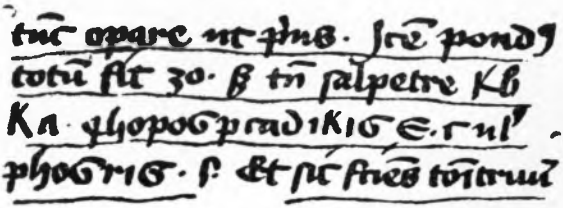
Gunpowder by itself could achieve little, it had to be manufactured in great quantities, it had to have the instruments, or weapons that could make use of its explosive quality. All this required industry and money. These things were in the towns then growing up, in the hands of the rising burghers or early capitalists. The kings of those days, constantly in conflict with various nobles, became more and more dependent upon the burghers of the towns. Gradually the forces accumulated which were to spell the end of the feudal system and the transition to the new capitalist system. As Frederick Engels put it:—

> "The provision of powder and firearms required industry and money, and both of these were in the hands of the burghers of the towns. From the outset, therefore, firearms were the weapons of the towns, and of the rising monarchy. The stone walls of the noblemen's castles, hitherto unapproachable,

fell before the cannon of the burghers, and the bullets of the burghers' arquebuses pierced the armour of the knights." *

For a long time there has been considerable controversy as to the origin of the invention of gunpowder. There have been incendiary or fire-throwing machines for at least 2,500 years. During the Peloponnesian wars a gadget like bellows and tube was used for spouting flames against stockades (forerunner of the flame-thrower). During the days of the Byzantine empire (later Roman, or Eastern empire, after the fall of Rome) a compound known as " Greek Fire " was used. This was a composition of oil of naptha with pitch, resin, vegetable oil and grease, to which was sometimes added various powdered metals. The Greeks had invented this, but its knowledge in the West was due to the Arabs who, having learned about it from their Mahommedan forefathers in wars against the Byzantine empire, used it themselves later in the wars of the Crusades. This " Greek Fire " and other fiery substances before it, was not, however, explosive but incendiary and certainly was never used to propel a missile as in the case of gunpowder.

For a long time many historians contended that gunpowder was invented by the Chinese and came to the West through the Arabs. Later historians such as Sir

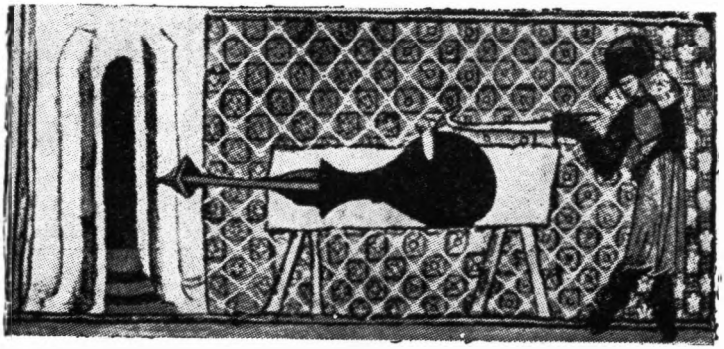


Photograph of the formula for gunpowder contained in a letter written by Roger Bacon in 1249 and now at the British Museum. It is written in Latin and means: " Of saltpetre take 7 parts, 5 of young hazel twigs,* and 5 of sulphur: and thou wilt call up thunder and destruction, if thou know the art."

* Anti-Duhring, " The Force Theory," p. 190.
* Plant from which charcoal is derived.

Charles Oman* have rejected this theory. However, it is known that the Chinese before the year 1,000 A.D. tied rockets to arrows to propel them greater distances. It is most likely that the Chinese had discovered the art of mixing, if not gunpowder, a very similar substance but this substance was used by them not for projecting balls or other missiles but more in the nature of rockets or things similar to present-day fireworks. Artillery using gunpowder and projecting missiles did not appear anywhere in the world until about the end of the 13th or beginning of the 14th century. The first undisputed evidence of anybody having discovered the formula for making gunpowder is contained in a letter written by Roger Bacon (an English priest) in the year 1249.

About a century later the invention, especially its application to artillery, seems to have been perfected by Berthold Schwartz, a German monk. It was thought for a long time that he was the inventor of gunpowder but we now know that he came on the



The first gun, pictured here, is in a drawing at the head of a dedicatory address given by Walter de Millmete to King Edward III on his accession to the throne in 1327. Note that the missile used is almost exactly like the quarrell, or bolt, used in the crossbow. The above manuscript is now in the library of Christ Church, Oxford.

* "History of the Art of War in the Middle Ages," vol. 2, p. 206.

scene much too late for that.

The earliest gun in Britain of which there is an actual picture, appeared in 1327 and was used during the reign of Edward III in the wars against the Scots and later in the wars with France.

For 200 years gunpowder was imported into England and not until Queen Elizabeth's time were powder mills built here.

Early Hand Guns.
1.—One of the earliest hand guns that was little more than a tube.

HAND GUNS.

The first guns were cannon, as technique wasn't yet sufficiently developed to produce anything smaller and effective at the same time. When hand guns eventually appeared, they were little more than miniature cannons as the idea of a hand gun had naturally been suggested by the earlier cannon. Most of these early hand guns were so heavy and cumbersome they had to be used by two men. They were known as hand culverins (culverin was a form of small cannon). Culveriners, as the operators of these weapons were called, were first used in England on a small scale during the later wars of the Roses, although they were operated by imported Mercenaries. The hand culverin had a bore of about ¾ in. or .75 in. If it is ~~borne~~ in mind that our modern rifle is .303 and that the anti-tank rifle is only .55 it is easy to grasp what a huge bore .75 is. The hand culverin was made of iron and joined by bands to a straight wooden stock.

Occasionally these miniature cannons were strapped to pike handles. (The day that the bayonet affixed to muskets replaced the pike 300 years later completed the cycle.) The earliest recorded use of the hand gun in England was in 1373. In 1386 the actual term " hand gun " appears for the first time, although in other countries they had been made earlier. At first,

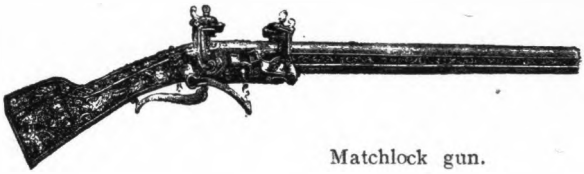
hand guns were merely tubes fixed to pieces of wood and ignited from the muzzle end. In other words, the very first hand guns didn't fire any shot at all, the idea simply being to frighten the enemy's cavalry horses by the flash. The first hand gun that fired any sort of shot was operated by a lighted match being applied to a touch hole on top of the barrel near the breech. It was held under the right arm, grasped by the left hand, while the right hand held the match.

Early Handgun used by cavalry.

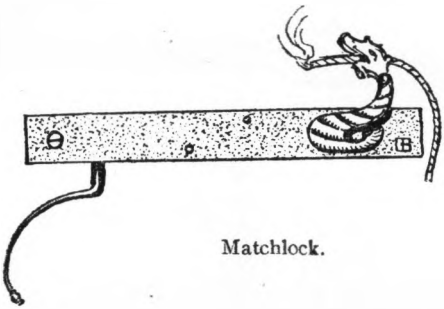
MATCHLOCK.

The first real step forward with hand guns was the matchlock. This weapon was also known as the arquebus* (invented in Spain about the year 1500) and also as the serpentin. With the matchlock, instead of applying a match by hand to the touch hole there was a special arrangement for firing the priming powder. It had a small pan upon which was placed the priming powder which was then covered by another plate that moved on a hinge. The match was grasped between the jaws of nippers which were called serpentin (this was similar to the cock in later guns and was a small lever bent in the shape of a serpent, hence the name).

As the trigger was pulled the match was made to fall upon the pan. In order to fire his gun the user had first to uncover the priming pan and adjust the match in such a manner that when it fell it would



Matchlock gun.



Matchlock.

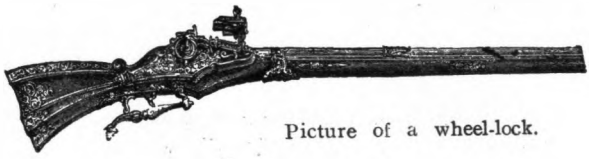
reach the powder. Very often he had to blow on the match to make it burn more brightly. As this was long before the days of cartridges the arquebusier (as the firer of this weapon was called) carried a flask for his powder, a bag of bullets and a small case containing the priming powder (hence the saying of Cromwell's days " Put your trust in God and keep your powder dry "). The matchlock was in use for two centuries. In the Rotunda (a museum in Woolwich) there is a matchlock or arquebus nearly 9ft. long, weighing 87 lbs. with a calibre of 1.3 in.

Some other types of hand firearms at the time of the use of the musket were the caliver and the fusil (from which comes fusilier) which were lighter types of muskets. The carbine was similar to the caliver but had a shorter barrel and larger bore.

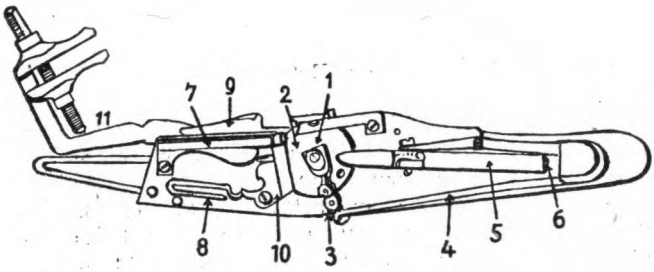
The blunderbus was shorter still and the bore still larger. The blunderbus was often a weapon more terrifying to the user than the enemy. An interesting point is that one particularly formidable blunderbus

* Arquebus is a corruption of arc-a-bouche, which means " Cupid's bow." It seems likely that this was originally a slang expression referring to the " deadly nature " of the missiles which were fired by the " arc-a-bouche."

called the Dragon gave the name " Dragoneers " to its users and from this comes the term Dragoons. In a like way the term Grenadiers derives from soldiers who used to throw small shells called grenades (before the modern hand grenade was thought of).



Picture of a wheel-lock.



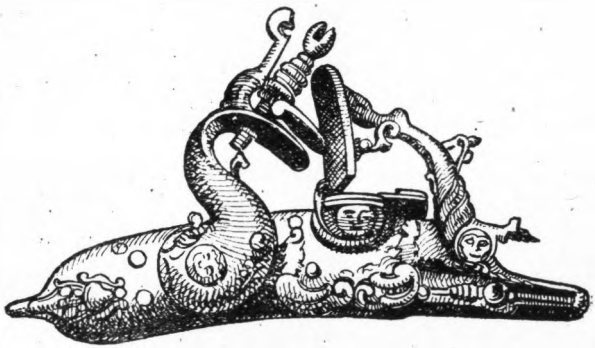
(1) Tumbler-axle. (2) Wheel. (3) Link-chain. (4) Main-spring. (5) Sear. (6) Prop. (7) Blade spring of bolt. (8) Spring of moveable arm of bolt. (9) Bolt to shut powder-pan. (10) Moveable arm of bolt. (11) Cock.

THE WHEEL LOCK.

The biggest drawback with the matchlock was the difficulty of keeping the match alight (especially in the rainy weather we are accustomed to in this country). An invention to overcome this difficulty and one which marked a big step forward was the wheel-lock, invented in Germany about the year 1500. The mechanism consisted of a wheel with serrated or file-like edges, protruding into the priming pan and fixed by its axle to the lock plate. A strong spring engaged with one end of the axle, while a key was fitted to the other end (something like a watch key). The key was wound, thus compressing the spring which turned the wheel. When wound up the spring was held in place by a catch attached to the trigger.

When the trigger was pulled, it disengaged the catch, releasing the spring and thus causing the wheel to revolve quickly. The file-like edges of the wheel struck sparks of fire from pieces of pyrites in the lock. These sparks fell upon the priming powder and ignited it. The principle is very much the same as with a cigarette lighter.

THE SNAPHANCE.



Snaphance.

As can be imagined, with the limited means of those days, the mechanism of the wheel-lock was a very expensive affair, and because of the expense it was used only by the cavalry. It was the expense that helped to bring about another advance. This was the snaphance. It was invented in Holland in the 16th century. The idea came from a group of Dutch poultry stealers, or poachers. (Snaphans as they were called—Haan in Dutch means hen.) They couldn't afford the expense of the wheel-lock, but at the same time they couldn't use the matchlock at night because the light would give them away. They devised a new way of firing the priming powder. Instead of the wheel-lock, there was a small hammer which struck upon a piece of sulphurous pyrites. The flashpan was similar to the wheel-lock, but the cover was worked by a spring and flew back as the hammer descended, thus allowing a free passage for the sparks while keeping the pan dry.

This snaphance had a fairly short life because it was really but a bridge between the wheel-lock and a simpler, yet far more advanced weapon, which was destined to last 200 years. This was the flintlock.

THE FLINTLOCK.

The principle of the flintlock is quite simple. People in ancient times knew that fire could be produced by striking flint upon steel. In the flintlock the hammer contained the flint. When the trigger was pulled and the hammer fell, it caused the cover of the flashpan, or priming pan, to fly open by use of a spring. The hammer (with its flint) as it descended struck the cover of the pan, causing sparks which set off the priming powder.

At first all the mechanism was on the outside of the lock, but subsequently was hidden, the mainspring being connected with the hammer by means of a tumbler.

Towards the end of the 16th century, the term musket makes its appearance. The original term musket comes from the Italian muschite, meaning sparrow-hawk. There was a custom in those days of naming weapons after different birds, according to their calibre (the 2 in. cannon was known as a falconet, the 5 in. as a basilisk, etc.).

Later, however, the term musket came to mean any hand-gun (except pistol) that had a smooth bored barrel as distinct from the later rifled barrel, and even to-day in the British Army small arms courses are sometimes called musketry courses. For many years the musket in England was known as the "Brown Bess," because of its popularity in the days of Queen Elizabeth. ("Good Queen Bess.") The term was still being used more than 200 years later in connection with the "Tower" flintlock musket used in the Napoleonic wars.

MUSKET AND BAYONET.

Before going on to the next stage in firearms a few words about the bayonet.

Once the musket had definitely outranged and beaten

the crossbow, it rapidly became the main infantry missile weapon. It was used in conjunction with the pike which was the weapon for hand to hand fighting. The musketeer fired his bullet, but early muskets sometimes required a hundred different operations, and the rate of fire was only about one or two a minute. In between rounds the musketeer was protected by a pikeman on either side of him. Thus in the 17th century there were usually two pikemen to every musketeer. This was not universally the case, development is always unequal, and early in the 17th century the great Swedish military reformer Gustavaus Adolphus had already reversed the ratio, making it two musketeers to each pikeman, but the general rule was two pikemen, one musketeer.

The principle of the bayonet is that it converted the musket into an effective pike after the firing finished and hand to hand fighting began. Thus every infantry soldier could be armed with a musket and pike (bayonet), increasing the firepower of most armies three-fold.

The bayonet is a French invention originating in the town of Bayonne (hence its name) and was first used in France in 1647. In 1698, Britain officially decided that the bayonet was to be the infantry weapon and that ended the days of the pike in Britain until 1941 when someone had the bright idea of arming home guards with them.

Opinions as to the value of the bayonet have always differed greatly. Some modern military authorities maintain that not only is the bayonet of little use now but that it never was of much value. Notable authorities of the past have also held that point of view, for example, Guibert in his " Essai Generale de tactique," written in 1772, states:

> " Bodies of infantry seldom make use of the naked steel, and when they march to the charge, they seldom meet near enough to cross bayonets."

It is also true that in the last war a large proportion of bayonet wounds were made after one body of soldiers had already given in or were trying to make a " getaway." Very few wounds were made in

" hand to hand " bayonet fighting as these sort of modern duels were very rare.

Yet with all the authoritative opinion and facts to the contrary, an even greater number maintain that not only was the bayonet always a useful weapon, but that it remains so at the present time. The fact is that every Government still issues bayonets to those of its infantry that carry rifles and the experiences of generations cannot be ignored. No doubt the very approach of the charge with bayonets unsettled the nerves of the side that gave in. In any case to condemn the bayonet for all times means to condemn the pike which preceded it. It must be remembered that the musket and pike were the infantry weapons until in the 17th century the bayonet attached to the musket replaced the pike, therefore the bayonet, especially in its early days, must have been a quite formidable weapon, in the hands of disciplined troops.

During the 18th century, for instance, the most successful troops advanced in close ordered line formation at no more than 70-80 paces a minute (marching pace to-day is 115-120 paces per minute), fired a volley or two and then charged with bayonet. This was the main infantry tactic in the early 18th century.

Before going off the point of the bayonet it is interesting to note the reason for this type of tactics in the 18th century. The reason is two-fold. Firstly, because of the very limited fire power of the musket of those days, but more importantly, because of the type of troops, the character of the soldiery.

They were very often hired mercenaries, sometimes including prisoners of war, and they could only be kept together by a most rigorous discipline and by having a high proportion of officers.

For instance, before the French Revolution the French Army had one officer to every 4 men. The officers had to keep a strict eye on their men and could only do so in a line which moved slowly and mechanically. Indeed, when the rifled musket first made its appearance and soldiers had to run and duck to keep alive, they were often condemned by their officers for cowardice.

The interesting point to note from all this, is that the type of weapons and the type of soldiers determine the tactics to be used.

With the development of the rifle and still more of the machine gun, the bayonet gradually lost most of its value. While in the 18th century a substantial proportion of the casualties were inflicted by the bayonet, at the Battle of Inkerman, 1853 (where the British used a superior rifled musket) 91% of the casualties were inflicted by the rifle fire.

In the Autro-Prussian War of 1866 when the Prussians used their breech loading needle guns, only 4% of the casualties were inflicted by the bayonet. In the Franco-Prussian War of 1870-71 only 1% were bayonet casualties. To-day the bayonet has a certain valuable role in house to house and room to room fighting, and has still a psychological value, the Germans being notorious for their distaste of cold steel, but the use of the bayonet is definitely very limited today and plays no major role in modern warfare.

THE RIFLE APPEARS.

The main principle governing the improvements and advances of the smooth bore weapons or muskets as we have seen, was in the method of firing. Every major advance, matchlock, wheel-lock, snaphance, flintlock, were advances in the method of firing the weapon.

As the methods improved and the consequent rate of fire increased, so an insoluble drawback to the musket became more and more obvious and more and more of an obstacle. What was this insoluble drawback? It was lack of both range and accuracy. At one time the musket was fired without taking any individual aim at all. This was when the barrel continued straight in line with the butt. When the slanting butt was introduced, it was possible to take an individual aim with a reasonable chance of hitting the target. But this " reasonable accuracy " could only possibly be up to a certain distance, perhaps 2-300 yards. Even the best and last muskets to be used could only hit the target once in twenty shots at 400 yards and that on

a target nearly 7 yards high and 2 yards wide.

Why was this so, and why could the problem not be solved with the smotoh bore musket? The answer is windage and type of bullet. The bullet, or ball, had to be smaller than the bore of the musket, in order that it could be dropped down the muzzle and fired out easily. Because of this difference in size there was a space between the outer circumference of the ball and the inside of the barrel. This difference or space is called windage.* By the time the ball reached the muzzle on its way to the target it had already lost a minute degree of its accuracy and the further it went the more accuracy it lost.

Also because of the windage, not all the gasses set up by the explosion hit the ball; some escaped along the sides in between ball and barrel. Thus it didn't have the power behind it to send it as far as cou'd the later rifle. As soon as any bullet is fired it is immediately in conflict with two forces, gravity, and wind or air resistance. Gravity pulls it down towards the earth, wind resistance drags at it and slows it up. With a bullet fired from a smooth bore, both of these forces have more success, particularly air resistance. What happens is that contact with the walls of the barrel cause the ball bullet to rotate. The inter-action of this rotation with the air resistance makes the ball follow a curved path, as when a cricket ball is made to curve in flight by the bowler giving it a twist. The best way to imagine what a ball bullet is like in flight is to imagine a cricket ball in flight, bowled by a spin bowler.

There was only one way in which this problem could be solved, and that was by inventing a method whereby the bullet could be packed tighter in the bore. It is quite clear that this was insoluble in a smooth bore. (The bullet would merely get stuck, or blow the barrel to pieces.)

Therefore the change had to be made inside the barrel itself, and the answer was rifling, a discovery

* Windage to-day is used in a different sense, it refers to the amount to the left or right to be allowed for cross winds when firing.

destined to be as vital to the future of the world as the invention of gunpowder itself. Because the first motive was merely to provide for a tight fitting bullet, the very first rifling consisted simply of a series of straight grooves.

The first rifle was a German invention, at the end of the 15th century. During the 16th century experiments were conducted to give the rifling a spiral twist. Once the idea of rifling at all arose, it wasn't long before the spiral idea came. As we have seen with crossbows, the knowledge that a spinning projectile was more sure and stable in its flight already existed. Yet, it took very many generations of mechanical and scientific advance before a satisfactory military rifle could be produced. The earliest patent for rifling in England was taken out in 1635. A Battalion of the Royal Americans was armed with the rifle in 1794, although it had been used in the same regiment unofficially as far back as 1758. This was the first occasion a British Military unit was armed with the rifle.

The first battalion of the Rifle Brigade in England was raised in the year 1800. The rifle used by this famous regiment was the Baker rifle, named after a London gunsmith of that name who designed it, and was .612 calibre (compared with the modern .303).

The difficulty of the early rifle was largely in the loading. It should be remembered that cartridges as we know them to-day weren't yet invented. The powder and plastered bullet were placed separately down the barrel, the bullet then being hammered home by a ramrod. So slow was this process that only one round per minute could be fired, which was slower than the later smooth bore musket.

For the advance of the disciplined, deployed line, firing perhaps two or three a minute and then charging with bayonet, the early rifle was no match. Thus at first the rifle was only for sharpshooters, huntsmen and sportsmen. The Americans of the 18th century were just such people and by the time of the American Revolution and War of Independence (1776-1783) the rifle was a widely used weapon in N. America. The American Revolutionary War marked the beginning

of a revolution in military methods, especially in infantry tactics.

The British infantry in their red coats and close ordered lines were helpless against the tactics adopted by the Americans. Because the Americans were fighting for their own freedom and therefore not likely to desert, it was possible for them to practise different tactics. Using their hunting rifles, they scattered in the woods and hills making use of all sorts of natural cover and potting away at the lines of redcoats. They introduced new skirmishing tactics, the groups of skirmishers being put well out in advance both in attack and defence. These skirmishers acted in combination with the main mass organised in columns (sometimes in lines, too). The main mass was held back as a kind of reserve or for manœuvring purposes and was launched only at decisive moments instead of at the beginning of every battle. These skirmishers were very important—in attack they weakened the resistance of the enemy's forward units while in defence they blunted the edge of the charging line of enemy infantry.

With the old smooth bore, such tactics were impossible for the very simple reason that the smooth bore was not efficient at medium range (for reasons already stated).

However, even in the times of the American Revolutionary War the rifle was not yet fitted for any large mass. To force the bullet down the barrel the barrel had to be made so short that it was a poor handle to a bayonet and was at a disadvantage in hand to hand fighting. For this reason the skirmishers were used in such position only when comparatively safe against either bayonet charge or cavalry attack.

Engels pointed out how in such circumstances the problem presented itself thus:

> " To invent a gun combining the range and accuracy of the rifle with rapidity and ease of loading, with the length of the barrel of the smooth-bore musket—an arm which is a rifle and also a handy arm of war, fit to be placed into the hands of every

infantry soldier.''*

Thus, with the introduction of skirmishing into the then modern tactics, the demand arose for such an improved arm of war. It is with the advent of the American Revolutionary War that the real process of improvement of the rifle really begins.

THE PROCESS OF IMPROVEMENT.

Although the Rifle Brigade armed with the Baker rifle was formed in 1800, the Baker rifle suffered from the drawbacks already mentioned and was only a very exceptional arm in the British Army. Waterloo (1815) was fought with the old '' Brown Bess,'' or as it was officially called, the Tower Musket (flintlock).

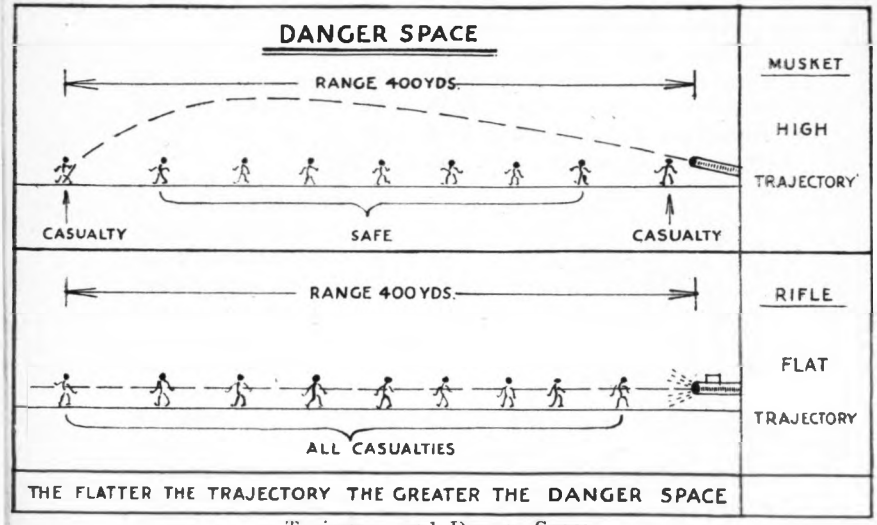
The first improvement came with the Lancaster Rifle, which was used in this country and abroad for 40 years. In the Duchy of Brunswick in 1832, the entire infantry was armed with the Lancaster, this being the first instance of rifled muskets (from now on we will just call them rifles) being given to the whole infantry of any one army. The Lancaster had an oval bullet for skirmishers and a spherical (round) bullet for the general volley.

Wild, a Swiss, improved the Lancaster. He introduced a bullet smaller than the bore in proportion to the Lancaster, and which took the rifling solely by the use of a plaster round the bullet. This produced good results up to 500 yards, and had a much flatter trajectory. A flat trajectory is of utmost importance because it increases the danger space of the bullet. The danger space means that part in the flight of the bullet when it is no higher than the height of a man, or about 8 ft. 6 in. for mounted fighters, therefore the flatter the trajectory, the more effective the bullet.

A flat trajectory is produced (to a large extent) by a small calibre. Weapons which have high trajectories, like mortars and howitzers, have a large calibre or bore in proportion to the length of the barrel.

A rifle on the principle of Wild's used in England was the Brunswick, and in 1836 the Rifle Brigade was equipped with this Brunswick rifle.

* '' The History of the Rifle ''—Engels, see reading notes at end.

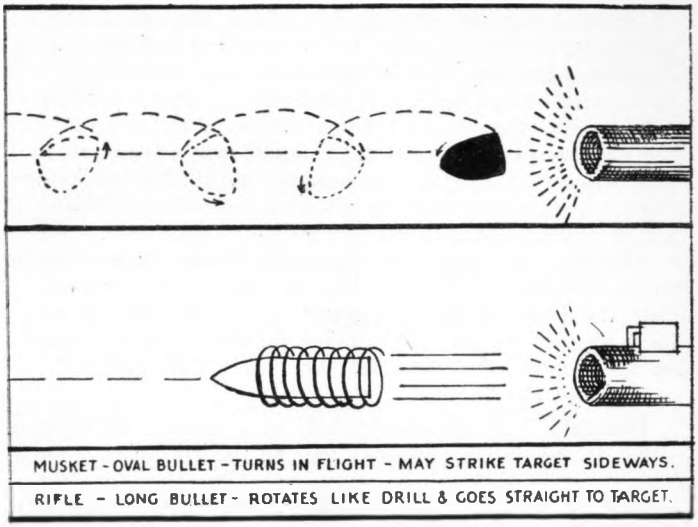


Trajectory and Danger Space.
This illustration is not supposed to be exact as there is no dead flat trajectory with any gun. It has been exaggerated in order to better convey the idea to the reader.

The drawback to all of these rifles was that the hammering required by the ramrod to force the bullet, once it had rolled down the barrel, to widen out and "take the rifling" made the bullet lose its shape. It became flattened and thus lost much of the lateral rotation (straight spin) produced by the spiral rifling. The result was that it lost much of its accuracy.

A French officer named Delvigne solved the problem. He saw that the clue lay in the type of bullet. He invented in 1826 a bullet which was a long cone-shaped affair, with a hollow made in its base. This took into account the use of the gas of the explosion.*

* In the modern automatic rifle the gas set up by the explosion is the chief force used to maintain the automatic action. For example, with the American Garand automatic rifle, when the trigger is pressed a round is fired, the cartridge case is then ejected and a fresh round fitted into the chamber and the breach automatically closed. Yet all this is done without the firer doing any more than pressing the trigger. The operation is performed mechanically, due to part of the gas being trapped at the muzzle and being utilised to operate a piston which is fitted just under the barrel.


MUSKET - OVAL BULLET - TURNS IN FLIGHT - MAY STRIKE TARGET SIDEWAYS.
RIFLE - LONG BULLET - ROTATES LIKE DRILL & GOES STRAIGHT TO TARGET.

The flight of bullets.
Here is a rough illustration of the behaviour of the two different types of bullets. The one fired from the smooth bore turns over in its flight. The one fired by the rifle rotates on its axis and travels more surely.

The gas entering the hollowed base of the bullet with a terrific rush caused the bullet to widen out and take the rifling. A British Captain Norton invented a similar type of bullet at about the same time though his invention wasn't taken up until 1851 by the authorities here.

Another big principle that Delvigne and Norton established was that an elongated shot was the only projectile suitable for a rifle, and this ended the day of oval and round-shaped bullets. What are the advantages of an elongated bullet? **Firstly,** the rotation on its longtitudinal axis (see sketch for illustration of what is meant by this technical term; it is something like the movement of a very fast drill, only it bores its way through the air), gives it a greater velocity or speed, and thus a greater accuracy. This rotation has a gyroscopic effect preventing the projec-

tile from being deflected in its course though it may be carried bodily sideways by air currents and gravity. Readers who have seen a gyroscope top that can spin on a knife's edge will get a good idea of what happens.

Secondly, the pointed shape reduces the effect of the air resistance (in much the same way as an arrow was supported by the air beneath it). The various efforts in our own time to produce streamlined bullets are in order to still further reduce air resistance.

Thirdly, the length of the bullet allows the calibre to be smaller without any loss of effect. That means that the bore of the rifle could be smaller and as we have already shown, the smaller the bore in proportion to the length of the barrel the flatter the trajectory, or flight of the bullet.

Fourthly, a longer bullet has more contact with the sides of the barrel (insides) and so the rifling may be less deep and cleaning becomes easier, there is less chance of fouling. In the older, deep rifled barrels, fouling was one of the biggest obstacles. Nowadays, after firing a hundred rounds, a " pull through " with a small piece of flannelette and a good oiling is all that is needed in actual battle, while a pint or two of boiling water poured through the barrel when there is time to spare perfects the job.

Aided by this new type of bullet, the rifle rapidly became a practical proposition for all infantry forces. The first of these practical rifles based on the new principle was designed by another Frenchman, a Captain Minie, and very soon all governments were having muskets turned into rifles. For example, when the superiority of the rifle was proven in the Crimean War the Prussian government had 300,000 muskets turned into Minie rifles.

There still remained drawbacks, however, one of the chief being that due to the friction caused as the bullet was propelled through the rifling, the solid point was often torn off, leaving the hollowed base in the barrel.

The grooves of the Minie rifle were too deep, especially for a weakened bullet (weakened because of the hollowed base). In 1851 the government of this country had nearly 30,000 produced, but they were scrapped

as unsatisfactory. After a series of experiments, the first Enfield rifle made its appearance. It was a modification of the Minie and took into account the Minie's weakness. This Enfield cum Minie rifle was first used in the Kaffir war that year (1851).

It was this Enfield rifle that finally superseded the musket as the official weapon of the British Army. It was just in time for the Crimean War, and gave the "Thin Red Line" at Inkerman (1853) the weapon with which it was to win such fame and glory.

THE BREECH LOADER APPEARS.

The weakness of the Enfield at the time of the Crimean War was that the calibre was too large; while the barrel was too delicate to take the bayonet. The Enfield of Crimean days was about the limit of development and improvement that was possible under the old system of loading from the muzzle end. It was the last muzzle-loading rifle to be used in the British Army.

Until a satisfactory system of loading from the breech end could be evolved the rifle as the chief infantry weapon was severely limited. To load a muzzle loader the soldier had to stand or at best crouch, he could not lie flat. Except in wooded or hilly country that offered plenty of natural cover and protection the soldier was exposed to great danger every time he loaded his rifle.

The idea of breech loading was not new at the time (middle of the last century) for there had been breech loading weapons hundreds of years previously but they were exceptional weapons and were not practical for the continuous and rigorous service required in the army. The reason lay in the difficulty of attaching the breech to the barrel in such a way that it could easily be connected and disconnected. It required quite a high level of technical development. Unless the fixing was very solid, the force of the explosion would prove too much. If it was solid enough to stand the explosion it was too cumbersome and slow to connect and disconnect quickly with the barrel. The two needs: solidity and speed, could not be combined in

the old days because the level of technical development generally and the metal industry particularly, were not up to the mark. By the middle of the last century this industrial handicap no longer existed. The technical and mechanical means were available and gunmakers turned their attention once more to designing efficient breech loading rifles. The job could at last be done—it was done.* Before the breech loader could be established securely, however, yet another important development was necessary, and that was in the method of firing the bullet. This was solved partly by the development of the cartridge and partly by the discovery of new ways of firing the gunpowder other than by flame or sparks. The method discovered was detonating or percussion powders.

A cartridge is a means of combining the bullet with the powder used for propelling the bullet. The very earliest cartridges were used by musketeers in 1586. They consisted of the bullet and the powder charge wrapped in paper and were known as paper cartridges.

To use them the end was either torn or bitten off, the powder then tipped down the barrel followed by the bullet and also the rolled up paper which helped to pack the bullet. The bullet and paper were then hammered home ready for use. These early cartridges were really measures to ensure the same amount of powder being used each time. Different amounts of powder give different results and it was difficult to judge an aim if the quantity of powder kept varying.

A cartridge could never be satisfactory until some other means of firing the powder could be discovered and it was thanks to precisely such a discovery by a Scotsman named Alexander Forsyth that an effective cartridge and an effective way of firing the rifle was

* An example of the mental hangover which the previous mechanical deficiencies left, is to be seen in a statement by one of the most famous authorities of the last century on Arms, W. W. Greener, who in his book "Gunnery in 1858" wrote "Notwithstanding all the skill and ingenuity brought to bear upon it, it is, we think, sufficient to prove that breech-loading guns cannot be made sufficiently durable to yield any reasonable return for the extra expense and trouble attending their fabrication."

made possible. His invention was known as the percussion lock. The invention was aimed to replace the flintlock method which had existed for about 200 years, not only in the old smooth bore musket but with the earlier rifles.

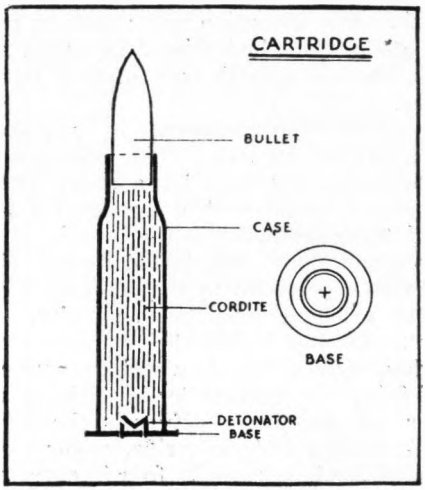
Forsyth started his experiments in 1793 and in 1805 perfected a percussion lock. The principle was that the detonating powder was hit a sharp blow by the hammer and as a result flashed through the touch hole and ignited the gunpowder in the barrel.

The percussion lock only lasted a very short time because it was superseded by the percussion cap based on the same principle only much simpler.

The percussion cap is still the method used in cartridges to-day. One of the drawbacks to every previous method of firing the gunpowder by lighting the priming powder was dampness. Even in the best days of the flintlock musket and early rifle, misfires caused by damp were as much as three to four in every ten. The percussion cap reduced this rate of misfires to about five in every hundred, while the modern ammunition to-day does not misfire as much as five in a thousand.

Forsyth's invention was viewed with suspicion by the authorities and it was not until 1834, nearly 30 years after his invention, that it was finally tested by the government, proved to be satisfactory, and in 1836 (as mentioned earlier) the Rifle Brigade was armed with the Brunswick rifle which used the percussion cap method. With this new percussion system it was not long before superior cartridges were being designed, one in particular known as the Boxer cartridge, after the inventor called Boxer, marking a milestone. This was made of coiled metal, the percussion cap being in the centre of the base of the cartridge. Under the gas of the explosion the metal expanded and sealed the breech, thus preventing any of the gas from escaping. After the discharge it contracted again making for easy extraction of the cartridge case. The cartridge also had a small rim at the base which fitted into the chamber and after the round is fired the empty case is extracted as the bolt is pulled backward to reload.

The cartridge (from then on until the present time)



The Cartridge.

consists of four parts: (a) the cartridge case, (b) the percussion cap, (c) the percussion powder or propellant charge, (d) the bullet.

A most important stage in the development of the cartridge and of the rifle generally was the invention of new forms of explosive powders or chemical mixtures to replace gunpowder. Gunpowder was the first explosive invented and consisted of a composition of charcoal, sulphur, and salt petre (or potassium nitrate). Gunpowder remained for 500 years as the sole explosive. With the big development of chemistry along with the development of industry as a whole, new explosive compositions were invented in the 19th century. They were made necessary for increasing the range of guns and for more rapid burning and explosion. Although one would imagine that all explosive powders burned at more or less the same speed, this is not so. Compared to such compositions as T.N.T., R.D.X., nitro-glycerine and others, the burning of gunpowder is quite a slow-motion process. For instance, to fire a shell from a modern big gun a distance of 10 miles, using gunpowder, sufficient charge to fill the

barrel as far as the muzzle would somehow have to be packed behind the shell. On the other hand, if T.N.T. was used to propel a bullet it would shatter the barrel before the bullet had time to leave the muzzle.

Gunpowder also produces a lot of smoke. In fact, gunners were usually enveloped behind a smokescreen of their own making, thus hiding their own target. Even a sniper would be revealed by the little puff of smoke set up from his shot. In 1886 nitro-cellulose powders were invented by Wiellie and adopted in the U.S.A., France and other countries, while in 1891 cordite was adopted in Britain. Cordite is a mixture of nitro-cellulose with a small amount of vaseline to stabilise it, that is to slow down the rate of deterioration during storage.

The term burning is used for simplicity's sake, actually there is a big difference between the burning and the detonation of explosives.

For example, a loose stick of cordite would burn freely at the rate of 12 inches per second: you could practically light a cigarette with it. Cordite in the confined space of a cartridge case, detonated, would burn up at the rate of several thousand yards per second. T.N.T. will burn slowly as well as detonate, the burning passes into detonation suddenly if there is a sufficient increase of temperature or pressure, such as occurs in a confined space. The type of explosive used in percussion caps is so sensitive that it detonates as soon as it starts burning, or under the influence of any sharp pressure or shock. Detonation is thus a higher stage than, and a different quality from, burning.

BREECH LOADERS FORGE AHEAD.

The first effective breech loading rifle used by an army was that known as the Dreyse needle gun. This worked on the percussion principle, a small needle worked by a spring piercing the cartridge, detonating the powder. This was used by the Prussians from 1848 onwards until the experience of the Franco-Prussian war of 1870-71 showed the need for further

improvements. But with their needle gun, the Prussians enjoyed for a time military superiority. Having tested it out in the war with Denmark in 1863, the Prussians speeded up the preparations for their war with Austria (1866) before the Austrians had time to produce and re-arm their forces with a breech loading rifle. The Prussians were thus able to fire in any position while the Austrians were handicapped by all the difficulties of the muzzle loader. This war was over in 7 weeks. There is no doubt that the breech loading needle gun played a great part in shaping the course of history in Europe, as it helped to decide the question of Prussian hegemony of Germany.

Between 1857 and 1861 four types of breech loading carbines were introduced in the cavalry of this country; the Sharps, Terrys, Greens and Wesley Richards. The War Office set up committees in 1864 and 1866 to report on breech loaders, and efforts were made to convert the Crimean Enfield into a breech loader. Firms were invited to tender suggestions and more than 50 were investigated. Finally, that designed by an American called Jacob Snider was adopted and was known as the Snider rifle.

THE SNIDER RIFLE.

This was adopted in 1864 but wasn't issued to the army until 1866 and was first used in the Abysinnian Campaign of 1868.

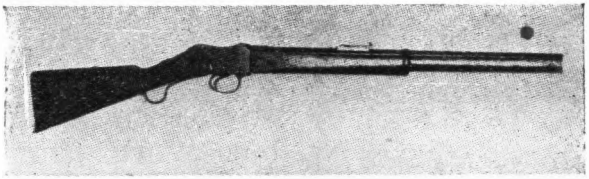
It had a breech block which worked on a hinge and swung up and out to the right for reloading. Boxer cartridges, mentioned previously, were used with the Snider rifle.

FRENCH CHASSEPOT.

This French rifle was adopted in 1866 in France and worked on the principle of the bolt action, i.e., the firing pin was contained in the bolt and the bolt action performed the function of loading, firing and extracting the empty round in much the same way as modern rifles.

MARTINI-HENRY RIFLE.

The next British model combined two different designs, one for the firing action, designed by an American called Martini, the other being a barrel designed by Henry. This rifle used the Boxer cartridge, was .45 calibre and was known as the Martini-Henry rifle and adopted in 1871 in Britain.



Last of the single shot rifles—the Martini-Henry Rifle.

LEE METFORD RIFLE.

Experiments were made for some time to reduce the calibre of rifles and to introduce a method of magazine feeding instead of a single feeding by the hand. Using a box magazine meant a great increase in the fire power of rifles, and is a landmark in the history of small arms. The Martini action precluded the use of a magazine feed. The calibre eventually adopted was the .303, which until this day remains the standard calibre of all British small arms. A bolt action was adopted, known as the Lee bolt action (after the designer). The system of rifling with the Lee Bolt was the Metford system, and this rifle became known as the Lee-Metford, and was adopted in 1888. (It should be explained that there are various systems of rifling, consisting of different turns of the spiral grooves, depths of grooves, etc. As a matter of fact, a new system of rifling has been designed for a new British rifle called the Battle rifle which in certain respects is similar to the rifling system of the old Brunswick rifle of 1836. The Brunswick rifle consisted of two grooves, as does the new Battle rifle. The Lee Enfield, which has been in fashion for years, has consisted of 5 grooves.)

LEE ENFIELD.

In 1893, after cordite was introduced in Britain, it was found that the erosive effect of the cordite tended to fill up the grooves so that the system of rifling was very narrow. Therefore a new system called the Enfield system was evolved, deeper and square shaped. Thus a new combination was made and the rifle known as the Lee Enfield rifle appeared and has existed up to our own time. The Lee Enfield superseded the Lee Metford in 1895 and was first used by the cavalry in the Boer War (1899-1902).

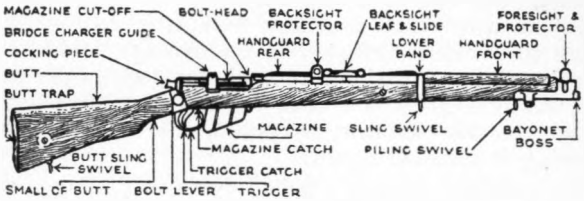
COMPLETING THE CYCLE.

There is no need to go through all the various models and many improvements of the last 50 years as this would be too technical and is not essential for our purpose which has been to trace the broad outline of the story of the rifle. To sum up so far, we have gone through three main stages, and are at present in the 4th and highest (so far), completing a long cycle of development from the first days of fire arms. The three stages passed are:

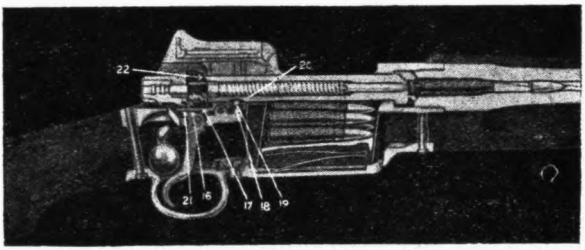
1. **Smooth bore.**—Low range, low rate of fire, inaccurate.
2. **Early Rifle.**—Moderate range, low rate of fire, fairly accurate.
3. **Modern Rifle.**—Long range, moderate rate of fire, very accurate.

The key problem of the 4th stage, i.e., of modern times, has been "how to intensify the rate of fire." In modern warfare, the combination of two basic factors has to be always sought. Fire power and movement.

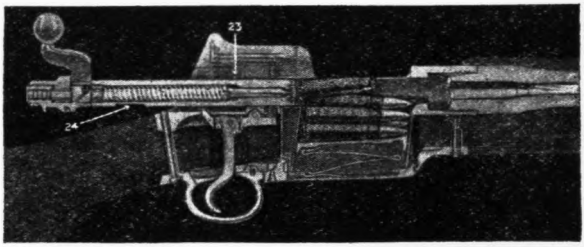
Sometimes these two factors have been in conflict with each other and before the present war, military authorities were often divided into two camps. Those who gave prime importance to fire power, and those who gave it to movement. However, experience is solving the problem by finding ways of satisfactorily combining both factors. With the rifle the problem of



(a) Exterior view.



(b) Interior view (before firing).



(c) Interior view (after firing, ejecting the empty case).

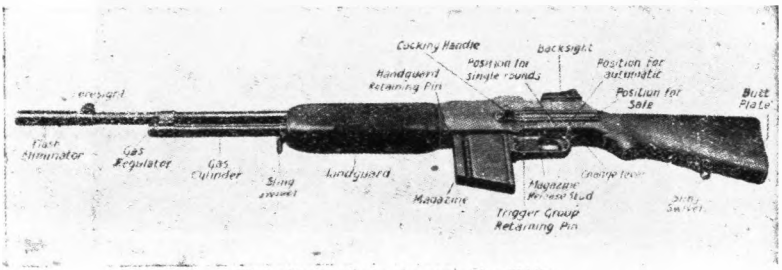
movement is easy enough, providing the rest of the army is mobile, because the rifle is light, easily manhandled, and can be fired from any position. The chief problem with rifles was therefore, the rate of fire. With the modern British rifle the average soldier cannot fire more than about 15 well aimed shots per minute, because he would have to load each shot separately into the chamber, by pulling his bolt back and pushing it forward again.

The problem therefore boiled down to finding a way of automatically loading each shot so that no effort on the part of the firer would be called for.

The solutuion was, of course, the automatic rifle. By the time the automatic rifle appeared (in the last war) the machine gun was already well established, as was the light machine gun. The automatic rifle was an attempt to transfer the principle of the machine gun to the rifle. This principle being the use of the gas of the explosion and a recoil or fuzee spring which automatically operated the lock or firing mechanism. In light machine guns there is usually a piston or return spring and rod which is forced back after firing by the force of the gas.

Some machine guns like the American Browning operate solely by a system of recoil without the aid of gas.

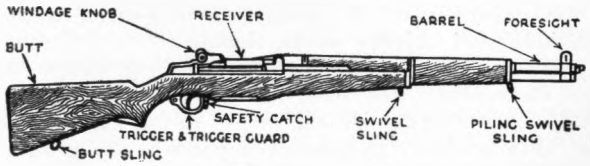
It is not our purpose to go into the origin and development of the machine gun as that is outside the scope of this book, but it is necessary to mention these one or two simple points in order to see the means



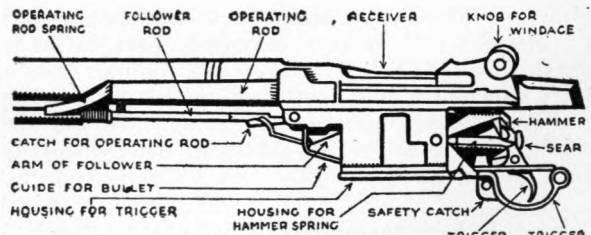
The Browning Automatic Rifle.

which already existed in the last war for the solution of the problem of an automatic rifle. The first automatic rifles, like the Browning automatic rifle of 1917, were more like light machine guns than rifles. The Browning, for instance, is very heavy (15 lb. 12 oz. as compared to the Lee Enfield 8 lb. 12 oz.).

It can fire automatically at a rate of 550 rounds per minute, that is if full magazines are continually being inserted, and somebody was available to carry them. Indeed, the weight of the rounds and magazines that could be fired in one minute would be as much as one man could carry if he had nothing else with him (approx. 40 lb.). Of course, in practise the rifle would never be fired at that rate, but that is what it is capable of doing. Its main value, however, is that it can fire 40 well aimed single shots per minute. With a rifle, single well aimed shots are the important thing. Bursts of automatic fire except at point blank range are of little use from a rifle, because the burst throws the rifle upwards and outwards and it cannot be controlled from the shoulder position. The only thing that controls the machine and light machine gun is a tripod or bi-pod, which weights it down. A rifle is a rifle



Exterior view.



VIEW OF MECHANISM

The Garand self-loading rifle.

and for machine gun work there are machine guns. The burst from an automatic rifle is useful on occasions (close fighting, culmination of an assault, etc.), but in the main it is speed at single well aimed shot firing that is required from the rifle.

For all these reasons, the Browning, while it was a big advance was not wholly satisfactory. Another development at about the same time as the Browning was the Thompson Sub-machine gun. This, too, is an immensely useful weapon for close in fighting but is not a lot of use at more than 60 or 70 yards.

The most useful automatic rifle, apart from some new ones used on the Soviet front about which no detail is available at the moment, is the American Garand self-loading rifle.* Its weight is only 9½ lb.: it has a magazine which holds 8 rounds. It can fire between 30 and 40 well aimed shots per minute.

As far as rate of fire is concerned, there is a limit with a rifle, the limit being the number of aims one can take, for the fire without aim is, quite logically aimless.

The modern automatic, or self-loading rifle completes the cycle, it has range, rate of fire and accuracy. It is a long step from the old hand gun, and is a tribute to the development of production in general and to technique and science in particular.

There was at one time a limit to the range that could be reached, the limit being the farthest the eye could clearly distinguish the target in the sights of the rifle. For ordinary purposes 600 yards is as far as any soldier ever has cause to fire his rifle. In fact, the average is nearer 300 yards.

However, there are special occasions such as sniping. Snipers play a very important part in modern armies. In the U.S.S.R. sniping is a high art, a whole snipers movement has grown up, with special badges for those who kill 100 of the enemy. To aid these specialists in the art of rifle shooting, there is a gadget known as a telescopic sight. As its name suggests,

* This is probably the correct title for what is needed. An automatic rifle is more of a machine weapon, it is the process of self-loading that is key problem requiring solution.

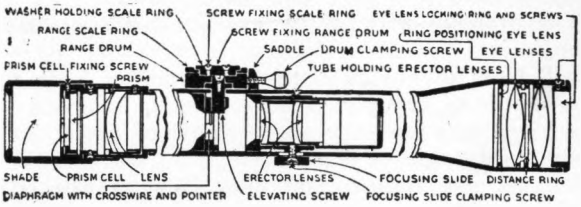


Diagram showing the parts of a telescopic sight.

it is a miniature telescope which enables the firer to more clearly distinguish his target and get it " between his sights."

SCIENCE WINS THROUGH.

Without the scientist and technician, the production of suitable firearms would be impossible. The artillery Commander who didn't know any mathematics would be of little use. The great arsenals without their skilled chemists would become out-dated in next to no time. The big gun factories without their physicists would soon be in a mess. But not only does the production and correct use of firearms depend so much upon the sciences that were already established, the development of firearms has led to new branches of science growing up. At first the branches were simply offshoots of other sciences, but developed to such an extent that for all practical purposes they have become separate, new sciences.

Take for example Ballistics, which is a branch of Physics. Physics is a science concerned with the behaviour of bodies (e.g., metals under heat). From physics arose the branch called Ballistics, concerned with the firing of missiles. That known as Exterior Ballistics deals with the motion of projectiles in flight through the air and their behaviour during flight.

This is extremely important, for there is no use in firing a gun if you don't know where the projectile will end up. The development of exterior ballistics has made it possible to calculate with great accuracy exactly what will happen to a particular kind of pro-

jectile if fired in a particular way.

The problem with which exterior ballistics has to grapple is:

> " How to calculate the trajectory or path of a projectile of any given characteristic, launched with a given velocity at a given angle of projection or quadrant angle of departure."

Scientists like Galileo and later Newton worked on similar problems in their time. Indeed, to solve the problem, certain laws of motion discovered by Newton are brought to bear.* The effect of the forces acting on the projectile are calculated and with the aid of algebra a graph of the behaviour of the projectile can be made. With the aid of science exact tables can be worked out, with allowances for weather, and other factors, on the behaviour of projectiles. The findings of ballistics are naturally very important for the designing of weapons and projectiles.

Modern artillery especially has developed an imposing scientific atmosphere. The power of modern artillery, which Stalin called " The God of war," is largely created in the academy. In the Dzerzinsky artillery academy in Leningrad, during the years 1935-40 more than 600 theoretical treatises and works were produced on ballistics and various branches of artillery technology.

The results of scientific research and calculations are embodied in the modern rifle. Every rifle is zeroed at the factory before leaving, and while the method of sighting is so simple that a child could understand it, it is nevertheless the result of considerable scientific and technical calculations.

Technicians to-day know the exact speed at which a bullet will leave the muzzle of the rifle.

In the case of the Lee Enfield in the illustration, it is 2,445 feet per second with the old Mark VII ammunition, it is higher with modern ammunition. It is important to know the muzzle velocity (as this speed

* The Law referred to here is known as Newton's 2nd Law of Motion, viz., " Mass x acceleration = force." For further particulars of the Laws of Motion see reading materials at the end.

is called) because there is an important difference between the behaviour of the air around a projectile when its velocity (speed) is below the velocity of sound, and when its velocity is above that of sound.

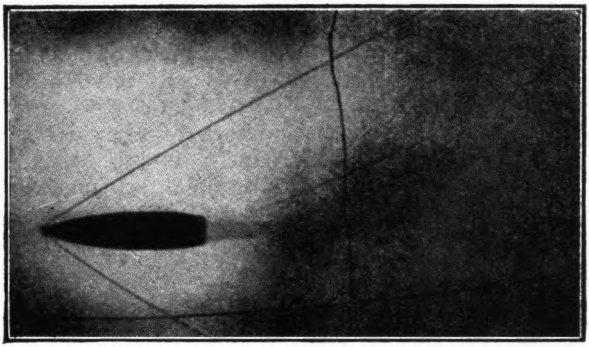
Now 2,445 feet per second is very roughly 1,700 miles per hour. The velocity of sound is about 750 m.p.h. (in our average climatic conditions).

When the velocity of the projectile is very low, the air resistance is low. As the velocity increases and passes that of sound, eddy currents are formed and these currents produce waves which move with the projectile. The total result is a much greater air resistance. Therefore when a bullet leaves the muzzle at 1,700 m.p.h. the decrease in the velocity for the first 6-700 yards is greater than in the second 6-700 yards, the reason being that by the time it has travelled the first 6-700 yards the velocity will have slowed down to below 750 m.p.h. (i.e., below the velocity of sound) after which the air resistance will be much less.

An interesting point arising from all this relates to the crack of the bullet. The crack is not as many people think, due to the gas of the explosion. What causes the crack are the eddy currents, which at 1,700 m.p.h. become pressure waves of great amplitude or sound. In other words, the crack of the bullet passing overhead is caused by the bullet tearing a passage for itself through the air. That is why it is impossible to fit a suitable silencer to a modern rifle because the crack takes place after the bullet has left the muzzle. Silencers are possible only on short range, or low velocity weapons like some pistols and revolvers. If the velocity of the bullet is less than 750 m.p.h. then a silencer to stifle the noise of the explosion is useful.

Even with the perfection of technique allowances have to be made for two other factors. One is the rotation of the earth, the other is the jump of the rifle.

The rotation of the earth is important for artillery and for aerial bombing, but not very important for rifle fire. The earth rotates upon its own axis from west to east. A projectile fired to the South in the Northern hemisphere would drift towards the right, in the Southern hemisphere it would be to-



Spark Photo of bullet leaving muzzle at about 1,700 miles per hour. Note the currents moving with the bullet.

wards the left. The amount of drift would vary according to the direction of the line of fire and the distance from the equator. The rotation of the earth from west to east is about 1,000 m.p.h. at the Equator and gradually decreases to zero at the North and South poles.

The second important factor is the jump. No rifle is symmetrical and so at the moment of the explosion there is a slight lateral jump which takes place before the bullet leaves the barrel. The drift caused by this jump will firstly be to the right and later to the left if the rifle has a left-handed spin.

The figures given for the American model of 1917, using 1916 ammunition provide a fairly clear example of this drift. At 100 yards the drift is $\frac{1}{4}$ inch to the right, at 300 yards it is nearly $\frac{1}{2}$ inch to the right, at 400 yards it is down again to $\frac{1}{4}$ inch, at 600 yards it is $1\frac{1}{4}$ inches to the left, at 1,000 yards it is $8\frac{1}{2}$ inches to the left, at 2,000 yards it is 10 feet to the left, and at 2,800 yards it is nearly 10 yards to the left. These figures are the sum of the lateral jump and the drift. They would be different if the rifle had a right-handed twist. However, for practical purposes, in a rifle, it doesn't matter a lot and some rifles are fitted with sights that make allowances for this drift.

Sufficient has been said therefore to show the impor-

tance of ballistics in particular and science in general in relation to firearms.

MAKING THE MODERN RIFLE.

Allied to modern science is the modern method of mass production. One of the reasons given in the testing of the new British Battle rifle was that the 2-groove system (as opposed to the present 5-groove) was more suitable for mass production which nowadays is a consideration of vital importance. The breech loading rifle marked the beginning of mass production, because it marked the stage of production and technique where mass production became possible. One result of the Austro-Prussian War of 1866 where the Prussian breech loading needle gun proved so superior, was a considerable expansion of the arms industry, so that the Franco-Prussion War of 4 years later (1870-71) became the first war of factory produced rifles in history.*

This modern mass production is, in the case of the rifle especially, accompanied by considerable craftsmanship. The final straightening of the barrel, for instance, is done by hand and eye, with a method that has not yet been superceded after half a century.

Before a rifle is put into production, scores of people work for months, in drawing offices, on designs for jigs and tools.

On the actual job in the tool room the greatest margin of error that is allowed in any tool or gauge is " 2/10ths of a thou," being 2/10ths of a thousandth part of an inch (.0002 in.), this being tool room standard.

In the actual machining of the job, everything that is humanly possible is done to make the process fool proof, but fine limits are the rule in gun making. The making of the barrel particularly is a job that requires

* " The Birmingham workers who produced most of the muskets used in the Crimean War (1854-1856) and 730,000 rifles for the American Civil War (1861-1864) made them (by a highly sub-divided labour process) in their homes or in the small workshops; the Franco-Prussian War was the first war of factory produced rifles " (Marxism,, Nationality and War, Part 1. by Dona Torr).

experience and delicate handling. From the rough turning to the finish grinding this part of the job is carefully nursed, every refinement of the craftsman's art being utilised, even to the extent of grinding or honing the barrel on the last lap, with a bit of tissue paper on a bamboo stick, to make it spotless.

The needs of mass production have increased the number of gauges and the amount of process checking required. The more unskilled and semi-skilled labour used, the more gauges and checking required. In the making of the new battle rifle the number of gauges may even be as many as 250. The various operations are spread out and simplified as much as possible, every operation being checked and counter checked until the job is ready for final assembly and final check. The rifle is then tested by firing under the supervision of technicians.

It is quite clear from all this that the government couldn't introduce new models of rifles every six months because by the time they reach the stage of mass production, which might be a year or more, they might not be so much advanced upon the previous rifle as to have merited the complications and hold up in production involved in switching over. Constant experiment and designing is one thing, going into production is another, although experiment and design are also directed towards furthering mass production methods.

WEAPONS AND SOCIETY.

We have traced the story of the rifle, of how it evolved, developed and became the scientific instrument of to-day. This story is also an illuminating example of the relation of war to society. It took 500-600 years after firearms first made their appearance until a rifle was made that was a satisfactory general weapon of war. Yet a mere 50 years later the automatic and machine gun are produced in huge factories thousands at a time. Why this contrast? Is it accident? Chance? Lack of brains in the past? No! The production of weapons of war is dependent upon the productive possibilities of society as a whole.

All the mechanical, chemical and other scientific means had to exist before our modern scientific weapons could appear. The constant urge and need for improvement of weapons on the other hand helped to develop the rest of the productive means of society. Once having arisen, the armaments industry played a decisive part in the further development of heavy industry as a whole. The Krupps combine is a good example of that.

The type of weapons, their specific features, have a decisive influence in determining military methods, strategy and tactics. The needs of military methods, especially tactics, in turn play a big part in the constant urge for new or improved weapons. Every schoolboy has read something in the popular Press about modern manœuvre tactics. He knows, too, that such tactics are possible because of the type of weapon that makes them possible, the tank, mobile artillery, planes.

That is one example of how the type of weapons mainly determine the tactics. It was the need to find a way of breaking the trench deadlock and defensive power of the machine gun that led in 1916 to the use of the tank for the first time. That was an example of how the needs of tactics created the urge for new weapons.

But neither tanks nor machine guns, neither the trench deadlock nor the modern type of manœuvre tactics, could have been possible, say, 200 years ago. It all depends on the level of society as a whole.

The early development of industry in Britain and the subsequent (and now traditional) skill of our workers, their ability in engineering and mechanics were all bound to be of great assistance in the early development of firearms.

The way that British methods of warfare developed was also peculiarly suited to the earlier firearms. From long before the days of gunpowder down to the present time British forces have always been at their best in close-ordered linear formation acting in battle at first on the defensive, maintaining a resolute disciplined defence until the moment was judged right for the counter-attack, particularly on the flanks of the

enemy. This " stoutness " of the British lines can be seen in most of our great battles.

At Waterloo the French advanced time and again in their deep column formation which was so often successful against other armies. The British forces, by maintaining a firm line in spite of heavy casualties, firing well-aimed volleys and then as the enemy column deployed into line for greater fire effect, charging with bayonet and scattering the enemy, the way was prepared for the cavalry to swoop forward into the disordered enemy and cut him to pieces.

The bravery of the " Thin Red Line " at the Battle of Inkerman in the Crimean War is known to every schoolboy. What is not always known is that it was the superior rifled muskets (Enfield) which had just been issued to the British forces and used by the men of the " Thin Red Line " that saved the day.

At the first Battle of Ypres in 1914, only the staunchness of British troops and their superb rifle fire, prevented a disaster from befalling the Allies. Indeed, the historians have referred to the men of Ypres as the " Thin Khaki Line."* So accurate and well trained were the riflemen with their 15 rounds a minute that the Germans concluded that the British had masses of machine guns, so intense was the fire.

The rifle was thus peculiarly suited for a long time to traditional British infantry methods.

It is the revolutionary changes in military methods and technique in the present war that has forced Britain to break away from tradition in spite of the efforts of many experts living in the past to hold us back.

This last point brings us to our final chapter—Constant Change.

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* " A History of the World War 1914-1918 " by Liddell Hart, p. 176.

CONSTANT CHANGE.

It is strange how so many experts in different ages have thought that their age was the limit of development and genius. For instance, Charles Boutell, the translator into English of a well-known French work on Arms and Armour (by M. P. Lacombe) and himself a considerable authority on the subject, has some notes of his own at the end of Lacombe's book. In these notes, written in 1869, he writes:

> " The ' needle '* and the various achievements of recent science and skill, with the rifling of the gun barrels, have almost, if not altogether exhausted the resources of gunsmiths, and produced weapons so perfect that any decided further improvement would seem to be scarcely possible."

Another interesting example given by M. Lacombe in his book relates to a letter written by Montluc, a celebrated French military leader in the days of Francis I (1515-1547). Referring to the casualties inflicted by the arquebus during a battle, he writes:

> " And brave and valiant men were killed with it in such sad numbers, and it generally happened that they were struck down to the ground by those abominable bullets which had been discharged by those cowardly and base knaves who would never have dared to have met true soldiers face to face and hand to hand. All this is very clearly one of those artifices which the devil employs to induce us human beings to kill one another."

At each stage of development horror has been expressed at " barbaric new weapons." In the early Middle Ages, Christians were forbidden to use the cross bow because it was such a terrible weapon. However, when the Crusades came along the rule was conveniently abolished as the cross bow was very effective against the Saracens.

One further example (and hundreds could be given): Machiavelli, in 1520, wrote a famous work called " The Art of War." He was the first to see the need of a new type of national state army, his proposed military reforms were in many ways two centuries

* The " needle " refers to the Prussian " needle " gun first used by the Prussian Army in 1848.

before his time. Yet in some way he was strangely blind. In his entire work he makes no mention of hand guns, nor in his illustrations for infantry formations does he include hand gunners. Yet there were hand guns in Italy 150 years earlier.

A hundred years earlier the Hussites (Czechs fighting under their great leader Jan Zizka for their national existence against the Germans), used hand guns to such an extent that almost a third of their army were equipped with them.

These three examples, all relating to considerable experts in their time and way, show how wrong it is to take up an attitude that " nothing is better."

Constant development and change is the only permanent law of nature and society. To keep in front, movements, people, states, must not only place their reliance upon the weapons and methods that at the time seem dominant, but should consciously and consistently be on the lookout for every new channel and idea. Methods of warfare, like all other aspects of society, do not stand still, and during war particularly, develop at an amazing pace.

The greatest enemy in the military field is rigidity, text-book mentality, conservatism. Even in our own day, the rifle, much less other weapons, is far from the limit of its development.

The day of the rifle itself is far from over. Although a complete cycle, or rather spiral, has been made since the days of the old smooth bore musket, there is a lot of room for further development.

Take, for instance, the three basic needs: (a) Range, (b) accuracy, and (c) rate of fire.

While the average soldier doesn't have cause to use his rifle beyond about 600 yards, that doesn't mean that it wouldn't be very useful to be able to use it for 2 or 3,000 yards. Theoretically, it can be used that far now, the mechanism and ammunition are good enough to shoot a bullet 3,000 yards and more.

But at present the soldier couldn't hit a man at 3,000 yards except by a fluke.

Why? Because the sighting method, even the telescopic sight, isn't sufficiently developed to overcome the physical limitations of the soldier (i.e., his eye-

sight).

But it is conceivable that the telescopic principle can be further developed to the telescopic camera principle in which the target can be brought into focus, in much the same way as an object through a camera.

If a soldier could hold his rifle square in front of him instead of at the shoulder, and manipulate a telescopic camera lens that synchronised with the actual sighting of the rifle, then a revolution in small arms will have been brought about. The idea may sound far fetched, but if warfare goes on long enough, such a development is not only possible it is inevitable. The science of optics is still in its infancy and applied to military needs it is a potentially powerful factor.

The further development of stream-lined bullets. perhaps even a smaller bore rifle, and new detonating powders will also add to the range and accuracy of the rifle. The development of new metal alloys and the plastics industry might result in rifles weighing no more than 6 lb., making movement more easy. As far as rate of fire is concerned, every improvement of range and accuracy makes rate of fire a more and more urgent problem. Britain has yet to mass produce a suitable self-loading rifle, and if it could arm all infantry rifle forces with such a weapon the fire power of the infantry would be increased by at least 50%. That would involve a greater mass production of ammunition, but that is the way of development, one thing leads to another, is related to and interdependent upon surrounding factors. Yes, the day of the rifle is not yet over, and perhaps won't be until the day of warfare itself is over.

There wasn't always war and there won't always be wars. The existence of war itself is not a permanent thing. The progress of science which has made our modern wonders possible, could, in the service of an enlightened community, create a world in which the necessity for war need never arise again, and the marvels of science could be put into the service of construction.

If this little book helps to increase the knoweldge of our own ability as human beings, then it will have served a useful purpose.

APPENDIX.

For Further Reading.

Those who find their interest stimulated sufficiently to urge them to go into greater detail will find this reading chapter useful.

In normal peace times it is possible to obtain through H.M. Stationery Office various official manuals and text books which give historical data. Unfortunately, these are unobtainable at the moment. For current data about different rifles and automatic arms there are several unofficial manuals obtainable at bookstalls. Of these I would recommend those issued by Messrs. Gale and Pouldens of Aldershot.

One of the first accounts that ever appeared on the early history of the rifle was by Frederick Engels. This consisted of a series of seven articles published over a period in the " Volunteer Journal for Lancashire and Cheshire " in the years 1861-2. The title of the series is " History of the Rifle " (by the author of a German account of the Newton Reivew), the author in question being Engels, who was an outstanding historian and theorist of the military art as well as an experienced fighter. This article has never appeared in any of the published books of Engels in English. It does appear in a two-volume " Selected Military Essays by Engels," published by the Red Army Publishing House, in Russian. I have tried to follow the method and sequence adopted by Engels in his articles. Engels' article starts with the first appearance of the rifle in 1498 and ends at about the time of the Crimean War (1853-4) while the rifle was still in its comparatively early stages of development. Nevertheless, Engels was able to foresee the general trend of development of the rifle and not merely to record the past.

A book written at about the same time as Engel's article and which contains much interesting data, is " Arms and Armour," by M. Henri Lacombe and translated into English by Charles Boutell. A similar but later book is " British and Foreign Arms and Armour," by H. Ashdown, though this doesn't con-

tain a great deal on the early rifle. The chief work on Arms and Armour is " European Arms and Armour," by Sir H. Laking.

A useful book is A. M. Low's " From Musket to Machine-Gun." This contains much interesting factual material, but it is not so much a logical account of the story of the rifle as a general narrative and deals more fully with modern machine-guns than with the evolution of the rifle.

For general information of types of past rifles the Encyclopædia Brittanica is well worth consulting.

For description of the early firearms used in battle in the later Middle Ages, Sir Charles Oman's " History of the Art of War in the Middle Ages," Vol. 2, is very good, and is in general a fine piece of historical work. For the role of different arms in more recent wars there are many good histories of different campaigns, including the official histories which may be found in good libraries. " The History of the Volunteer Infantry " is also useful in this respect. For a more detailed treatment of the science of Exterior Ballistics there has recently been published " Exterior Ballistics," being Chapters X and XII of " Elements of Ordinance," by an American. Lt. Col. Tom J. Hayes. This is a first-class textbook. A very thorough account of automatic arms may be obtained in " Automatic Arms," by two Americans, Melvin H. Johnson, Jnr., Charles T. Haven.

For the more scientific side, especially for more explanation of the laws of motion, and the work of Galileo and Newton, one can't do better than to consult Lancelot Hogben's " Science for the Citizen." Those who would like to know more of the relation of weapons to the development of science should read Professor Bernal's " Social Functions of Science."

For the chemistry aspect, i.e., the development of explosives, the standard reference is Marshall's " Explosives " (3 vols.). However, for the general reader there is a very good Penguin " Explosives " by John Read.

This list is by no means complete, but it is a start and the author would be glad to advise readers on any aspect of further study.

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